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Language as a mental travel guide

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Abstract

Gilead et al.'s approach to human cognition places abstraction and prediction at the heart of "mental travel" under a "representational diversity" perspective that embraces foundational concepts in cognitive science. But, it gives insufficient credit to the possibility that the process of abstraction produces a gradient, and underestimates the importance of a highly influential domain in predictive cognition: language, and related, the emergence of experientially based structure through time.

Transcending the present moment – referred to by Gilead et al. as "mental travel" – is indisputably central to human thought: It encompasses not only predicting the future, but also traversing distance on several other psychological dimensions. In order to predict, we need to abstract, and in order to abstract, Gilead et al. argue, we rely on a diverse toolkit comprising three distinct levels of representation. We are skeptical that there exist qualitatively distinct levels of a representational hierarchy, and instead suggest a graded continuum from "modality-specific" to "categorical" representations. Further, we contend that a key factor in promoting development of this gradient – underappreciated in the proposed toolkit – is language.

As Gilead et al. suggest, a consequence of the drive to reduce prediction error is the emergence of representation at multiple levels of abstraction. But, these levels need not be qualitatively distinct: for example, evidence suggests that conceptual knowledge is represented on a posterior-to-anterior gradient along the temporal lobe, with modality-specific information becoming less salient more anteriorly (e.g., beagle–dog–animal; for a review, see Davis & Yee 2019). Critically, the role *language* plays in processes of abstraction and prediction deserves greater recognition (for discussion, see Yee 2019). Language is perhaps *the* quintessential example from human cognitive behavior of (levels of) abstraction, prediction, and the relationship between them. Both language comprehension and production may build on more general predictive mechanisms involved in action planning and understanding (e.g., Pickering & Garrod 2013; see also Altmann & Ekves 2019), and language is, by definition, abstracted away from objects and events. And in addition to providing a useful model of prediction and abstraction at multiple levels of representation, language plays a *functional role* in facilitating these functions, and thus, "mental travel."

Many formal models of abstraction in language exist, but here we focus on work describing prediction and the emergence of abstract category structure as a function of accumulating knowledge of the contexts in which experience is grounded (Elman 1990; see also Altmann 1997). Jeff Elman's work with the simple recurrent network (SRN) is the quintessential example from a *computational* standpoint of abstraction, prediction, and the relationship between the two (Elman 1990; 1993). Through accumulated experience of sequences of words, categorical distinctions such as between parts of speech (e.g., noun and verb), and between classes of nouns and verbs (e.g., edible objects and intransitive verbs) *emerge* in a network given the task of predicting the next word in the sequence.

Gilead et al. perceive an insufficiency in models exhibiting an "undifferentiated, continuous hierarchy of mental representations of different levels of abstractness." Yet Elman's SRN *was* undifferentiated *computationally* (hidden layer units all functioned identically). After learning though, it was not undifferentiated *functionally*. Similarity relationships in its equivalent of the external world (language input to the SRN) were maintained in its acquired internal representations, and these allowed the SRN to predict the space of possible inputs at the next point in time. Hierarchy was only categorical to the extent that hierarchical clustering is categorical (different clusters would exhibit different hierarchies). Abstraction in Elman's work was *graded*, meaning generalization was graded also – a desirable property in a probabilistic world. Importantly, and unlike Gilead et al.'s framework, the computational principles that underpin the successes of the SRN (which have since been shown, in deep recurrent neural networks to scale up to the demands of realistically large vocabularies) are general principles of *learning and development* (Elman et al. 1996).

The emergence of increasingly abstract representations (not just in language) may rely on domain-general neurobiological mechanisms for tracking systematicities across space and time (for discussion of how one such mechanism may apply to abstract concepts, see Davis et al. 2020). However, a problem for any experience-based model of abstraction is how we sample enough of the world to track those systematicities and converge on shared meaning. Here, language comes in again: It allows us to experience more of the world than we could *via* direct experience alone. Experiencing spoken, signed, and written words – and their distributional patterns of co-occurrence both with other words in sentences and with the real world – opens a window into other people's (embodied) experiences. Distributional language statistics are a rich source of knowledge (e.g., Louwerse 2008), enabling us to make predictions about things not directly experienced.

Language also facilitates prediction and abstraction in ways non-linguistic thought does not. For example, labels may penetrate through the representational gradient by operating directly on mental states (Elman 2009). Although classical thinking holds that language is merely a means to communicating our thoughts, more recent work has shown that language has a functional role not only in higher-order thought, but also perception (for a review, see Lupyan 2012). A consequence of language's influence across the gradient of abstraction is that concepts do not operate only at the modality-specific level: labels may (among other things) help integrate modality specific information in higher-order association areas. Gilead et al. cite meta-analytic findings that lexical-semantic tasks tend to activate higher-order brain regions far removed from modality-specific areas (Binder et al. 2009) as "compelling evidence" against distributed, modality-specific models of cognition. But, these activated higher-order regions are integral to multimodal integration and conceptual access *via* labels. Furthermore, because there is diversity in the modalities in which different things are experienced (e.g., sunsets visually, vs. thunder auditorily), conceptual representations reflect that diversity (e.g., Davis et al. in press).Thus, when experiments average over dozens of diverse concepts, activity in the various modalities that contribute to each one is likely to be washed out.

Abstraction is a process, and this process engenders a gradient, not qualitatively distinct levels in a representational hierarchy. Moreover, an account emphasizing "representational diversity" to address how humans use prediction and abstraction to transcend the present moment should recognize the ubiquitous role of language. Not only does the scientific study of language processing offer well-tested, formalized frameworks for understanding how abstract structure emerges (e.g., Elman 1990; see also Altmann 2017), but language itself plays a functional role in facilitating "mental travel" *via* its integral role in prediction and abstraction.

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